Dryden Flight Research Center
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DRYDEN HANDBOOK

CODE O

OPERATIONS ENGINEER'S HANDBOOK

Electronically Approved By:
Director, Flight Operations Directorate

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1.0 INTRODUCTION

The purpose of this handbook is to describe the duties of the Operations Engineering Branch. It is a reference for Operations Engineers, other employees at the Dryden Flight Research Center, and guest employees to help achieve the goals of their projects.

The handbook is available to the Dryden staff and to the public on the Interactive Document Management System (IDMS) that is a compilation of policies and procedures that govern the conduct of business at the Center. This handbook refers to documents in the IDMS that are hyper linked with this text for easy access using the Dryden Intranet.

2.0 WHAT IS AN OPERATIONS ENGINEER?

Operations engineers are assigned members of project teams consisting of project managers, engineers, mechanics, technicians, and artisans. The operations engineer is the Flight Operations representative who identifies, assigns, and coordinates the tasks that must be done to get a vehicle ready to conduct its mission. The responsibility requires in-depth knowledge of the organization, skills, and science required to make a unique research aircraft safe and successful. The duties require the operations engineer to work directly with all project team members, particularly the crew chief, project manager, and the project chief engineer, as well as the craftsmen, other engineers, and mechanics that support the project. These duties consist of six major functions:

- Aircraft technical management
- System safety
- Flight readiness
- Flight support
- Post flight activity
- Peripheral activities

3.0 AIRCRAFT TECHNICAL MANAGEMENT

As the technical manager of an aircraft the operations engineer:

- Controls configuration to be certain the vehicle can successfully and safely perform its missions
- Schedules work to ensure timely achievement of objectives
- Coordinates activity to avoid conflict in commitments and tasks

- Informs crews and researcher investigators of the configuration of the aircraft, the operating characteristics, and the operating limitations

This function is not to be confused with the role of the aircraft crew chief who is responsible for the maintenance and servicing of the aircraft, the logs, and records. The operations engineer maintains close consultation with the crew chief for understanding of the aircraft systems, configuration, and condition. He also writes and approves aircraft work orders that allow the crew chief to do special work to implement changes to the aircraft that are not routine maintenance or repair.

The configuration is managed according to a configuration management plan prepared by the project manager for research vehicles, or by the operations engineer for support aircraft. This is discussed in the next section on Configuration Management.

Project events are usually scheduled by the project manager. The project team must then identify tasks to achieve the milestone events. After that the operations engineer must prioritize the tasks and assign the work to the shops. In collaboration with the shops the operations engineer will estimate the time required to accomplish each task and schedule the work to meet the delivery requirements of the project plan.

Because the shops support a number of programs it is essential that these tasks be coordinated among all the project operations engineers according to priorities set by the Project Directorate. Weekly meetings shall be conducted to plan the work and evaluate progress. Participants will include operations engineers of each project and representatives of each shop or branch involved.

The operations engineer keeps parties informed of technical aspects of the equipment by writing Operations Fact Sheets for each aircraft. The Fact Sheet is an addendum to an Operator's Handbook and describes everything that flight crews and research investigators need to know about a vehicle that differs from the baseline configuration described in the Operator's Handbook. These Fact Sheets are vital for safety and mission success.

Operations engineers prepare maintenance and modification instructions that are not included in aircraft manuals or technical directives. These instructions include specifications (drawings) and procedures that ensure airworthy implementation, as well as inspection requirements that confirm conformance to the specifications.

Operations engineers prepare test plans and procedures for research flights and brief the project teams prior to flight so that roles and responsibilities of everybody involved are clearly understood. These plans and pre-flight briefings are vital to safety and mission success.

3.1 Configuration Control

The purpose of configuration management is to avoid unknown or unauthorized changes that increase the risk of accidents or failures. Depending on functional responsibility the plans are written by the following:

- Project managers for research vehicles **(DCP-P-016)**
- Operations engineers for support aircraft **(DOP-O-001)**
- Mission managers for airborne science aircraft **(DOP-Y-006)**

Configuration management plans describe the roles and responsibilities of parties involved, assign authority for approval of configuration changes, explain the processes for implementing configuration changes, and describe the documents used to record configuration changes.

Regardless of who writes the plan, an operations engineer is the Operations Directorate's representative for configuration management of every flight vehicle operated at the Center. The responsibilities and authority is established in the configuration management plan for the assigned vehicle.

The Configuration Control Office issues drawing numbers and updates these drawings per engineering changes or redlines.[1]

Other functions of the Operations Engineer in the area of Configuration Control, include the maintenance of up-to-date weight and balance documentation on the aircraft[2], and the issuance of the Fact Sheet[3] which is in effect an addendum to the Pilot's Flight Manual.[4] The Fact Sheet describes in detail any configuration change which impacts the handling or flying qualities of the aircraft or the operation of its systems from a piloting point of view.

4.0 SYSTEM SAFETY

4.1 Role of the Operations Engineer in System Safety

Closely tied to Configuration Control is the System Safety Plan[5] which will vary in scope, depending on the size of the project and the sort of experiments involved. This plan specifies how the project intends to address and manage hazards as they are found.

Hazards may be identified on a hazard analysis, typically prepared by the Operations Engineer and, or, the appropriate Project Engineer(s), with inputs from outside sources that may have previously performed similar analyses on the items in question. Hazards may also be found from discrepancy reports filed on experiments or the airplane, discrepancies entered in the aircraft workbook, or system failure analysis performed on the experiments.

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[1] **DOP-O-022** Drawing Control Process
[2] See Section 7.1.4.
[3] **DOP-O-006** Fact Sheets
[4] **DOP-O-300** Flight Operations Manual
[5] **DCP-S-004 & DHB-S-001** System Safety Plan

The project engineers are to identify what the hazards are, assess the risks involved, and determine recommendations to management on how to eliminate, control, or accept the risk. Hazards that cannot be eliminated or mitigated to a low enough severity and probability category become part of the project's "accepted risk list."[6]

5.0 FLIGHT PREPARATION ACTIVITY

5.1 Flight Preparation Defined

Flight preparation deals with the many activities related to making an aircraft ready for flight. This can vary from a very large effort when it follows a major modification, to an abbreviated "turn around" process if the aircraft is to make successive flights without significant additional modification. The following paragraphs describe the "full blown" effort, which follows major modification of the aircraft. Appropriate deletions for the turn around situations are negotiated between the Project Engineers and the Operations Engineer.

5.1.1 System Functional Test **(DCP-O-011)**

These are very comprehensive tests of all the various aircraft systems, whether experimental or not. In the case of non-experimental or "standard" systems conforming to Military Specs or Tech Orders, those documents will usually prescribe the proper functional tests. Experimental or highly modified systems require special formal procedures for functional test, which are generated by appropriate Dryden personnel or by a NASA contractor.[7]

The Operations Engineer must be involved in the development and execution of such functional tests, especially if the experiment in some way interfaces with the aircraft systems or if the safe operation of the aircraft depends on the successful operation of the experimental system being functionally tested.

The nature of the experiment will determine if System Functional Tests are repeated between every flight; or only after long periods of down time, a major configuration change, or major system malfunction and repair.

5.1.2 Ground Vibration Tests (GVT) **(DOP-F-730)**

These tests are performed if a significant structural modification has been made, which might have an effect on the flutter characteristics of the aircraft. In these tests the concerned portion of the aircraft is artificially excited by vibrator motors or "shakers" and the structural response is measured and analyzed by engineers with experience in structural dynamics, (who are also responsible for generating the test requirements).

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[6] **DCP-S-002 & DOP-O-305** Hazard Management

[7] **DCP-O-011** Preparation and Release of System Procedures

The Operations Engineer is not responsible for completing the details of these tests, viz., developing the procedures, gathering the test data and analyzing the data. However, the Operations Engineer is responsible for ensuring that no experiment, test or modification damages the aircraft, and is thus essential in the project determination of when GVT's are required. The Operations Engineer is also involved in the preparation of the aircraft for a GVT and supports the completion of the test as required. GVT's may be time consuming, depending on the type of modifications made to the aircraft, and Operations Engineer is responsible for making the aircraft available for these tests.

5.1.3 Instrumentation Calibrations **(DOP-R-405 & DOP-O-405)**

When the instrumentation system is ready and functionally tested, the various data channels are calibrated. This involves the application of known inputs to the various sensors and a measurement of the signal received by the data recorders on instrumentation bus monitors. Calibration procedures are generated by the Instrumentation Engineer or Technician. The calibration procedures may be more involved when special components, such as strain gages, need to be instrumented and calibrated for flight.

5.1.4 Aircraft Weight and Balance **(DOP-O-023)**

Modifications to aircraft which change its weight or the distribution of its weight require that a new weight and center of gravity (c.g.) location be determined. If the weight change is not extensive, and if the specific location of weights removed or added is clearly identifiable then simple calculations will suffice, using the previous weight and c.g. locations as a baseline. However, in the case of more massive or complex weight changes, the aircraft is generally reweighed using either portable electronic scales or, preferably, the very accurate platform scales at the Edwards Air Force Base Weight Hangar.

The Operations Engineer is the keeper of the Weight and Balance Book, and consequently is responsible for promptly updating it after any relevant change to the aircraft configuration, or after the yearly required weight and balance.[8]

Some airplanes will be more sensitive than others to the c.g. limits allowed, but in all circumstances the Operations Engineer is responsible for determining the c.g. and maintaining the aircraft within its allowed limits or informing the project and management of any condition when the aircraft c.g. limits could be violated. Such situation is an operational hazard.

Occasionally moment of inertia data are required for an aircraft or aircraft components. Such measurements are usually performed in Dryden's Flight Loads Laboratory under the direction of the Aerostructures Engineering Branch.

[8]Air Force publication T.O. 1-1B-40: Technical Manual, Weight and Balance Data; and Naval Air Systems Command publication NAVAIR 01-1B-40: Technical Manual, Weight and Balance Data.

5.1.5 Combined Systems Test (CST) (DCP-O-011)

When all functional tests of the individual research systems are completed, and the aircraft is essentially ready to fly, an all up, end to end, test of the entire aircraft and control room is performed. This test uses the Western Aeronautical Test Range[9] (WATR), a staffed control room, preferably with the same personnel who will serve during actual fights, and all required aircrew members on board. During Combined System Test (CST), engines are run so that all systems operate on aircraft power alone, and if required, the aircraft may taxi to a predetermined location on the taxi way. The CST, like the Functional Tests, is not repeated between every flight, but usually only before a first flight after an extensive modification to either the airplane, the control room, or both. A formal written set of special test procedures is developed for a CST, usually by the Project Engineers. Engineers who are Principal Researchers on the experiments to be flown must participate in the development of CST procedures.[10]

The CST plan will involve all the aircraft systems, whether modified or not, as well as the research or experimental systems. During CST all the critical parameters are checked in the control room, if possible, for accuracy as well as functionality. The Operations Engineer must be familiar with the operation and interaction of critical flight components or subsystems, thus he or she ought to be intimately involved with the development and execution of the test, and may even be the one who collects information from other project engineers to put together the test procedures.

5.1.6 Preflight Checks (DCP-O-011)

These checks are similar to System Functional Tests but are not nearly as comprehensive. They may vary in their content from flight to flight, and parts may be omitted for a succession of "quick turn around" flights, but some form of preflight check is performed for every flight. Preflight Checks for "standard" systems are generally performed in accordance with Military Tech Orders applicable to the particular aircraft, or their equivalent for non-military aircraft. Preflight Checks for experimental or highly modified systems are generated by NASA Subsystems Engineers or a NASA Contractor.[11]

The Preflight Checks are covered in the various checklists that are completed before flights. The Operations Engineer is responsible for verifying that all the needed Preflight Checklists are completed and modified as required. The checklists having to do with the airplane are to be generated and modified by the Operations Engineer with inputs from other project members, including the avionics lead technician and the Crew Chief. The Operations Engineer should maintain the original versions of the Checklists and make copies available to mechanics and technicians as required.

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[9] DOP-F-100 through DOP-F-107 Western Aeronautical Test Range
[10] DCP-O-011 Preparation and Release of Systems Procedures
[11] Ibid.

5.2 Flight Preparation and The Operations Engineer

Throughout the flight preparation phase, the Operations Engineer's role is, as always, that of the aircraft Technical Manager as described in Section 4.0, with added emphasis on his or her collaboration with the other organizational elements involved in flight preparation, the engineers and technicians from various disciplines, all of whom play an important part in this activity. Arranging schedules, determining support requirements, developing "work arounds" when difficulties arise, dealing with discrepancies, generating and/or approving test procedures, are all part of the Operations Engineer's task.

In the case of an initial flight following a major configuration change, a Flight Readiness Review (FRR) will usually be conducted by an independent review board.[12] The Operations Engineer is among those required to brief that board, usually, but not exclusively, presenting pertinent data regarding any reconfigured aircraft hardware. The Operations Engineer may need to present other information, such as changes to the Flight Operating Limits, changes to the Emergency Procedures, and other pertinent items which are usually included in a new revision of the Fact Sheet.[13]

In addition to presenting information to an FRR board, the Operations Engineer may be asked to be part of an FRR board to review other flight projects.

The Operations Engineer participates in the approval process for all aircraft test procedures. This includes System Functional Tests, Combined System Tests, and Preflight and Postflight Checks, which originate locally. Procedures originating under contract or from another agency which are appropriately approved by that contractor or agency, are subject to the Operations Engineer's review approval.[14]

Throughout the flight preparation phase, the Operations Engineer is the focal point for information concerning the status of the aircraft, and is the spokesperson as to its go/no-go condition.

5.2.1 The Operations Engineer and Life Support **(DOP-O-007 & DOP-O-010)**

The Life Support group performs all maintenance and modifications to the flight crew equipment and aircraft ejection mechanisms. This includes repairs as well as time scheduled changes or upgrades. The Operations Engineer must coordinate with the Life Support group the availability of the aircraft for the timely completion of all egress system work.

Cockpit modifications must not interfere with the safety of the aircraft crew during normal operations or egress, or in the event of an ejection. Cockpit modifications that have a potential impact on the normal life support or egress systems must be reviewed by the Cockpit

[12] **DCP-X-009** Airworthiness and Flight Safety Review Process
[13] **DOP-O-006** Fact Sheets
[14] **DCP-O-011** Preparation and Release of Systems Procedures

Committee.[15] All cockpit modifications, major or minor, should also be reviewed with the project pilots, to ensure proper ergonomics. All work orders which make cockpit modifications must be approved by the Cockpit Committee.

5.2.2 The Operations Engineer and the Project Pilot

The Operations Engineer must keep all the pilots associated with his or her assigned aircraft informed of all modifications or upgrades on the airplane. Such information must also be documented on the aircraft Fact Sheets, which may take the form of changes or additions to the Pilot's Flight Manuals.[16] However, this information (including memo form addenda to the Fact Sheet) regarding changes to the pilot's interface with the aircraft should also be briefed personally to the all pilots who will fly the aircraft prior to the first flight after the incorporation of the changes.

6.0 FLIGHT SUPPORT ACTIVITY

Included in this area are those activities directly related to flight operations, among which the major events are as follows:

6.1 Technical Briefing

This is a briefing given by the Projects Office and engineering disciplinary people in which the technical objectives, of upcoming flights, and/or technical accomplishments of previous flights are presented. This briefing is normally given well before the scheduled flight to permit a thorough review of the flight plan by all concerned.[17]

The role of the Operations Engineer in a Tech Brief is similar to his or her role in an FRR; i.e., the Operations Engineer is to present any pertinent changes to the aircraft or to its operation.

6.2 Crew Briefing

This is a briefing given by Flight Operation Directorate, usually by one of the project pilots and assisted by other project members as necessary, in which the operational details of the flight are presented, along with a run through of the final flight test cards. Such items as crew assignments, weather forecast, radio frequencies, chase requirements, mission rules, emergency procedures, etc., are discussed and reviewed.[18]

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[15] **DOP-O-007** Cockpit Safety Review
[16] **DOP-O-300** Flight Operations Manual
[17] **DCP-X-008** Technical Briefings
[18] **DOP-O-300** Flight Operations Manual

6.3 Day-Of-Flight Checks

Before take-off a set of procedures is followed in which all aircraft servicing is verified, and the step-by-step process of bringing all systems on-line is completed. As the aircraft undergoes its final checks the control room instrumentation is verified for adequacy; also pilot or crew entry occurs during this activity. The Operations Engineer is responsible for developing these procedures with the help of other project members and oversees their prompt and adequate completion. For simple situations, in which aircraft modifications are minor, the standard checklists provided by Military Tech Orders or their commercial equivalent may suffice, but where new complex experimental configurations are involved, a special checklist is developed by the Operations Engineer to ensure the dovetailing of pilot and ground personnel functions in order to attain the desired sequence of events. The Day-Of-Flight Checks conclude prior to the start of take-off, at which point the pilots test cards take over.

6.4 Mission Control **(DCP-O-003)**

During flight, the mission is usually, but not always, controlled from one of the control rooms at Dryden, where system health and aircraft performance are monitored real time using telemetry data downlinked from the test aircraft; the assigned flight controller provides the voice communication link between the ground personnel and the flight crew.[19]

The Operations Engineer's primary task in the control room operations is to provide information on aircraft subsystem operations real time. This may include trouble shooting and determining "work arounds" to safely complete the research mission.

The Operations Engineer may also be the flight controller[20] or a flight engineer; however, these roles depend largely on the nature of the research and project needs.

6.5 Flight Engineer

Operations Engineers, as well as other engineers, may also be assigned as Flight Engineers. Flight Engineers are usually needed for experiments too complex for a single crew member to perform, viz., when a pilot is flying a high work load maneuver and has to operate on board research equipment simultaneously. The availability of Flight Engineers minimizes the need for multiple pilots on a single aircraft while maintaining the quality of the research data obtained. This role is particularly helpful for Operations Engineers in obtaining a better situational awareness of flight operations.

7.0 POST FLIGHT ACTIVITY

Post flight activity involves recovery of the aircraft, any inerting of systems that may be required, instrumentation and aircraft system post flight servicing/inspection, the recording of any

[19] **DCP-O-300** Flight Operations Manual
[20] Ibid.

discrepancies, and similar activity. A post flight debriefing is given by the pilot and others including chase pilot(s) and control room team members if they have pertinent comments.

The Operations Engineer directs the aircraft activity as usual, and participates in any debriefings.

The post flight period is relatively short and soon gives way to flight preparation if a turn around is planned, or a return to modification status if configuration is to be changed significantly.

8.0 PERIPHERAL ACTIVITIES

The foregoing sections of this handbook have presented the tasks which make up the core of the Operations Engineer's function, but there are others which frequently fall to him or her, which are very important, the most significant of which are briefly described in this section.

8.1. Ad Hoc Review Committee Participation

Special committees are appointed from time to time for specific purposes, such as Design Reviews, and Flight Readiness Reviews. Membership for these committees is selected to match the major disciplines involved in the project under review, but since operational aspects and aircraft subsystems are almost always involved, the membership generally includes an Operations Engineer.

8.2. Accident/Incident Investigation **(DOP-O-305)**

Accident or incident investigation usually involves an Operations Engineer. Depending on the magnitude of the accident/incident, an investigation may require a large board with requirements for formal reporting to NASA Headquarters, or a single investigator with only local informal reporting requirements.

8.3 Source Evaluation Board **(DCP-A-005)**

Major competitive procurements will generally involve a formal source evaluation process to grade the various proposals and thus assist in selection of contractors (s). Membership in the Technical Evaluation Team usually includes an Operations Engineer.

8.4 Engineering Design **(DCP-P-016 & DOP-O-001)**

The Operations Engineering group provides Dryden with an ever increasing engineering design and analysis capability. The resources of the group may be accessed by all projects, including non-flying projects, that need support in mechanical or electrical design or analysis.

9.0 RESOURCES FREQUENTLY USED BY OPERATIONS ENGINEERING

9.1 Process Specification System **(DCP-O-006)**

Process Specifications give specific instruction on how to perform a particular process in a standardized way so as to achieve consistent results without re-inventing the process each time. References to specific Process Specs are to be found throughout this handbook as appropriate to the subject under consideration. The Operations Engineering Branch maintains an up-to-date Process Spec Manual in the Branch Office. The Process Spec System is administered by the Dryden Q/A Office.

9.2 Tech Order Library **(DOP-O-505)**

The Tech Order Library is administered by the Dryden Aircraft Maintenance Section. This library is a valuable source of Tech Orders for military aircraft, military specifications and standards, and other aircraft related data. Up-to-date specifications and other drawings of standard military equipment are maintained as part of an extensive file and are available for quick access.

9.3 Photo Lab

The Photo Lab provides a variety of photographic services. Documentary photos can be taken on fairly short notice by experienced photographers. Aerial photograph and video capabilities are also available. This service can be quite useful to the Operations Engineer who wishes to record significant stages in a reconfiguration process for future reference. A photographic work order is required to obtain photo services; both color and black and white photos are available.

9.4 Duplication Facility

A Reproduction Facility, or print shop, provides a variety of printing services. An important service for the Operations Engineer is the drawing copier for any size drawing.

9.5 Weight and Balance Hangar (USAF) **(DOP-O-023)**

The Air Force Weight and Balance Hangar located along the main taxi way at Edwards Air Force Base provides weight data for aircraft of almost any size. Massive platform scales imbedded in the floor structure give very accurate readings from which center of gravity location can be calculated. This facility is operated by the Air Force.

9.6 Flight Loads Laboratory **(DOP-F-710 & DHB-R-004)**

The Flight Loads Laboratory is used to perform combined mechanical and thermal load tests of structural components and complete flight vehicles which simulate the actual flight conditions. The Lab is also used to perform strain gage loads calibrations on aircraft components, such as actuators and links; and on complete aircraft structures, such as wings, tails and fuselages, for flight loads measurements. Proof loads tests for flight certification of modified aircraft structures, and new aircraft structural components are also performed at the Lab. For thermal and, or,

mechanical structural testing of aircraft, the Operations Engineer is responsible for providing the aircraft in its proper configuration, and generally, also has the responsibility for the design and fabrication of the aircraft laboratory hardware required for the testing; for example, load reaction fittings that attach directly to the aircraft. The Operations Engineer also participates in the Test Readiness Reviews, and is often an active participant during the running of the tests.

9.7 Walter Williams Research Aircraft Integration Facility

The Walter Williams Research Aircraft Integration Facility provides flight simulation and data recording capabilities which may be useful in determining aircraft operation at different flight conditions. Flight test cards are usually flown on a simulator by the project pilot or a project engineer before they are flown on the airplane. Some simulators include hardware in the loop capabilities which are useful for testing and trouble shooting components.[21]

[21] **DOP-F-710** Simulation Facility